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SALIENT FEATURES IN THE GEOLOGICAL HISTORY OF AUSTRALIA, WITH SPECIAL REFERENCE TO CHANGES OF CLIMATE

Salient Features in the Geological History of Australia, with Special Reference to Changes of Climate. Contributed by Professor W.G. Woolnough, D.Sc.,University of Perth, W.A.

THE PRE-CAMBRIAN AGE

Rocks of definitely ascertained Pre Cambrian age occupy a great area throughout Australia, while others, almost certainly of this age, underlie a vast extent of the surface of the continent. In South Australia and in the Northern Territory the association of fossiliferous Lower Cambrian strata with older schists defines the Pre-Cambrian age of the latter most satisfactorily. In Queensland. New South Wales, Victoria, Tasmania and Western Australia, lithological evidence points to the existence of Pre-Cambrian rocks but stratigraphical and palæontological tests leave open the possibility of the beds belonging to some part of the Lower Palæozoic group. In South Australia three fairly well defined lithological series are represented by the rocks of Eyre's Peninsula, by those of northern Yorke's Peninsula, and by those of the Mount Lofty arid Barossa Ranges respectively, which will probably be found to correspond with definite breaks in the geological sequence. The Mount Lofty and Barossa Range beds (Barossian series) are certainly altered sediments, including lime stones, but they yield no information as to climatic conditions in the Pre-Cambrian time. The same may be said of the Northern Territory beds. In most of the remaining Pre-Cambrian areas the rocks are granitoid in character, or else very highly metamorphosed crystalline schists.

THE CAMBRIAN AGE

Evidence as to climatic conditions in the Cambrian time is much more abundant and conclusive. In the Lower Cambrian beds near Adelaide there is developed a very important and extensive glacial series (Sturt River glacial beds). Some distance higher up in the series come limestones (Brighton limestones) and higher still great reefs of limestone (Archæocyathinæ limestones). It is possible, though by no means certain, that these limestones may indicate a change of the climate. The Archæocyathinæ limestones have certainly the **habit** of coral reefs, but the organisms are of so primeval a type that it would be rash to assume that they indicate a climate similar to that required for the growth of reef corals at the present day. In the Northern Territory. Cambrian time was ushered in by great volcanic activity. Then followed the deposition of immense beds of limestone, probably unsurpassed in extent anywhere in the world. Evidences of shallow water origin are not wanting, hence the accumulation of thousands of feet of limestone

may be taken to indicate long continued subsidence. The upper beds of the Cambrian system (Roper River quartzites and Mount McMinns beds) are of very shallow water origin, and the predominance of red beds may indicate aridity of the adjacent continental surface.

THE ORDOVICIAN AGE

In Ordovician time, deep sea water stretched over Southern Australia, and very constant and characteristic **graptolite** beds are widely distributed. This deep ocean did not cover the whole of the continent, since in the "Larapintine system" of Central Australia the fancies of the Ordovician system is quite different. Here were very shallow water conditions, evidenced by the occurrence of pseudomorphs of common salt crystals. In all probability Northern and Western Australia were occupied by continental land at this time.

THE SILURIAN AGE

During the Silurian period conditions changed considerably, and South-eastern Australia was covered by shallow sea water. Immense lime stone beds occur at intervals from Tasmania to Northern Queensland and, as these are built up largely of true reef-building corals, the inference of a warm climate is not without justification. Evidence of volcanic activity are widespread.

THE DEVONIAN AGE

In early Devonian time the south-eastern corner of Australia was occupied by an immense range of acid volcanoes, which built up the Snowy River porphyries. They may have attained altitudes of upwards of 15,00 feet above sea level.

Lying upon their denuded surfaces, but still of Middle Devonian age, are extensive coralline limestone, probably indicating the existence of warm shallow seas. These limestones occur at intervals from Gippsland, through to New South Wales to the Burdekin and Fanning Rivers of Queensland.

Late Devonian time was marked by instability of the land surface, and by rather rapid alternations of marine and terrestrial conditions. The occurrence of red beds may indicate aridity of climate, but no deposits of salt or gypsum were produced. The earliest abundant plant remains (**Lepidodendron australe**) belong to this stage.

THE CARBONIFEROUS AGE

In Carboniferous time the instability of level noted above continued, and became even more pronounced, so that interbedded marine and freshwater strata are a feature of this formation. Towards the close of the period, too, volcanic activity became very widespread. The organic life of the time was abundant and varied; its abrupt cessation, and the strong contrast presented by the succeeding fauna and flora, indicate that a warm climate obtained during Carboniferous time.

THE PERMO-CARBONIFEROUS AGE

. Permo-Carboniferous time witnessed a return of intense glacial conditions, perhaps the most intense that have ever visited Australia. Victoria, South Australia, parts of Tasmania, and nearly the whole of Western Australia were continental land. Over this continent stretched a great, slow-moving ice sheet, wearing, polishing, and scratching the rock surfaces, and transporting

fragments for hundreds of mile. From the directions of the scratches it is clear that the main centre of ice distribution in Eastern Australia. lay to the south-west of Tasmania. That is to say, high continental land existed, at that time, not far from what is now the eastern end of Jeffrey's Deep. After reaching sea level, near the border between Victoria and New South Wales, the ice sheet broke up into icebergs and "rafted" great blocks of rock far to the northward. These erratics are abundant in the Hunter River coalfield and in the Macleay River district of New South Wales, and the icebergs floated well within the limits of the tropics in Queensland, Central Australia, and Western Australia. There is a remarkable alternation of shallow water marine beds with freshwater beds in Australia. It is in these freshwater beds that the most extensive of our productive coal measures were developed. Glacial action was not continuous throughout the whole period, but, after the first great glacial epoch, passed away for a time, and reoccurred to a much more limited extent later. The fauna and flora of the Permo-Carboniferous system offer a contrast to those of the preceding period so marked that, as above mentioned, a stupendous change of climate must have occurred in the interval indicated by the unconformity between the two formations.

THE LOWER MESOZOIC AGE

The Lower Mesozoic (Triassic or Trias-Jura) beds of Australia seem, for the most part, to follow those of Permo-Carboniferous age, with very little evidence of great changes in the distribution of land and sea. In New South Wales and in Western Australia there appears to have been continuity of sedimentation. Nevertheless, there is a most striking **life-break** between the two systems, which, in absence of evidence of great land movements or long lapse of time, must be taken to indicate an extensive and relatively rapid change of climate. All the Lower Mesozoic beds of Australia are of freshwater origin, and, in Queensland, Victoria, Tasmania, and South Australia, contain workable coal measures. On the western slopes of the Main Divide of Eastern Australia and in Western Australia they contain supplies of artesian water.

THE UPPER MESOZOIC AGE

In Upper Mesozoic time (Cretaceous) there was a very extensive transgression of the sea over the continental surface. In all probability, Australia was severed into two or more great continental islands lying to the east and west of a large Mediterranean sea. In this latter, and in the ocean waters beyond the islands, were laid down marine beds. Those of the Mediterranean sea, widely developed in Queensland, Northern Territory, and South Australia, and to a smaller extent in New South Wales and Western Australia, supply vast quantities of artesian water.

THE EARLY TERTIARY AGE

In early Tertiary time the whole continent was subjected to a tilting movement, rising on the north and subsiding on the south. The former portion became dry land, but the sea transgressed extensively over Tasmania, Victoria, South Australia, and Western Australia, and laid down thick beds of limestone. Climatic conditions appear to have been quite mild. Extensive volcanic eruptions occurred along the borders of the old cretaceous sea.

THE LATER TERTIARY AGE

In later Tertiary time came the gradual uplift, expelling the sea from the continental surface, and causing the formation of extensive plateau surfaces. Volcanic action on a large scale was widespread, and, in Western Victoria and South-eastern South Australia, continued to a very recent date. That the climate of Australia was much moister during this period than it is at the

present day is shown by evidences of former great extension of lake basins now dry or much shrunken, and by the remains of gigantic extinct animals, including crocodiles and turtles, in the now desert areas of Central Australia.

A third great glacial epoch occurred during late Tertiary time. On this occasion, continental ice-sheets were not developed, but the highlands of Tasmania and of the Australian Alps were covered by ice-caps, which descended some 3000 feet below the present summit levels.

The latest phases of the geological history of Australia are to be read from the distribution of land forms. These indicate that earth movements of a plateau-forming character are still taking place; the separation of Tasmania and New Guinea from the mainland, and the development of the Great Barrier Reef of Queensland, are important. incidents in this phase of geological history.

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